Course Name: I Think Biology

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W8L43_Speciation (Case studies)

Hi, welcome back to this second lecture on speciation in the week of species, speciation and biodiversity. My name is Jayantee Mukherjee and let's get started. So in this lecture, I am going to introduce how to interpret or read phylogenetic trees. So you all might have seen a picture like this. Just a second, let me pull my pointer out. A picture like this, yeah.

These are called phylogenetic trees. Now in our iThink biology book, we have talked about these trees at least two times and also have elaborated this in our chapter in in the primers. You can see there is a chapter on evolution where we have talked about what are phylogenetic trees and how do we read them. I would highly recommend that you go and read this chapter as well as the chapters where we have discussed in more details one of the case studies that we are going to talk today.

So let's get started. What are phylogenetic trees? So phylogenetic tree can be thought of as a family tree that represents evolutionary relationship among organisms and is used generally normally by scientists to classify organisms. So when you have studied, I think taxonomy or planned animal kingdom classifications, you might have seen a tree like this. But it is generally to understand the relationship between extinct, extant means the ones that are living and with their ancestral species. So you know how to construct that ancestry of tree is what a phylogenetic tree tells us.

And it is hypothesis because we cannot 100% be sure of what had happened in the past because lot of these trees are constructed based on fossil records or some kind of DNA material that had existed at that time taking those things and mostly also morphological evidence of fossils we construct these trees based on bits and pieces of puzzles like a puzzle, you know. That's how this whole information is gathered together. So in this lecture we are going to talk about two very interesting case studies which has relevance to our Indian context and see how phylogenetic

trees are constructed and more importantly gain more knowledge about speciation and the process of speciation. So the first case study is speciation in Dipterocarps. So some of you might be you know little bit worried or puzzled, look seeing this term dipterocarps.

What are these? I am sure many of you might not have heard the term dipterocarps as such, but a lot of you have heard the term or heard about sal trees, right sal or shorea robusta. This belongs to the family Dipterocarpaceae. We have extensive areas under sal trees in the north India where it is grown growing in dry to moist deciduous kind of forest. It is a deciduous tree and hence in the winter months it sheds its leaf.

However dipterocarpaceae is family of plants with of lot of evolutionary significance. It is a family which comprises only trees, only of trees, okay. So it does not have any herbaceous species or you know climbers or any other habit form. So it has 16 tree genera which comprised, which comprises 695 species within them and it is a Pantropical family for example which means that it occurs along the tropical regions of the whole world. However the highest diversity is seen in Borneo where if I give you an example just of this genus Shorea, Borneo almost has 128 or something species of Shorea itself where at least 96 of them are endemic species which means it is not found anywhere else in the world. So you can imagine how very biodiverse this Borneo islands are and also how rich this dipterocarp is in the that area.

So what is the significance of that or what is the relevance of that?

And you can see Shorea robusta is of course was named after John Shore, who was from the East India Company and he was doing these floristic survey during that time, found these species and it was named after them. But it once we started discovering more and more species now we know that Shorea is represented by 196 species across the world whereas some other dominant genera are Hopea, Dipterocarpus as well as Vatica. All these genus are represented in the forests, tropical forests of India. So if you see the fruits of Shorea is like this and it is called the wind fruit which means when the wind comes it kind of not only uses gravity to fall down and disperse but also it has wind which can take it to a little bit more distance than the gravity, okay. So this is the main process of dispersal in this species and of course it has relevance in the evolution of this species when we see it.

So in 2022 Bansal et al came up with this study where they also got interested in the family of Dipterocarpaceae and wanted to trace the origin and evolution of this family. They their aims of this study was to trace the origin of this family, define the role of climate in the dispersal pathway of this family and resolve the you know paleo-geographic history of lowland Dipterocarpus, okay. So the this as you know when a scientist or researcher does this research they have these two, three aims which they want to address by constructing this phylogenetic tree. However, for the scope of this lecture we are just going to concentrate on the first aim which is trace the origin and evolution of Dipterocarpaceae. So now let us see how did they

achieve this objective.

Dipterocarpaceae is within that family, there are three sub-families as you can see Monotoideae which is distributed throughout Africa, Madagascar and South America. As you can see Africa, Madagascar, South America will be a little bit drier climate than the Seychelles, India as well as Indomalai and Southeast Asian region,okay. So the middle one is Pakaraimaeoideae, which is predominantly occurs in South America and Dipterocarpoideae which as you can see Seychelles, India and Southeast Asia, Borneo being one of the most biodiverse in this family. So they framed their questions and this is how they actually asked or collected data, okay. So they collected data from different kinds of fossils.

You will see the main fossil evidence was from almost 72 million years ago where they collected fossils from Sudan, then was in the Paleocene where lot of Indian fossils were gathered through this similar kind of investigations and again the neotropical or the more new world species evidence was collected through macro fossils. So initially the Sudan and Indian evidence or Poland evidence are called micro fossils because they are very micro and micro fossils you can see would be wood, leaf or fruit. These were the evidences collected. So gathering all these evidence so through different you know fossil scales or fossil strata then they put together the information to come up with something like this. This is the phylogenetic tree of the family Dipterocarps and you can see I have highlighted this.

Most of the, in the early Cretaceous which is approximately 102.9 million years ago, approximately 103 million years ago, this radiation or migration or you can call radiation started from afrotropical regions towards other regions of the world. So initiation that it originated from the, in the late Cretaceous in this area of Africa. Then slowly you can see most of these lineages are in green which means these evidences are from Cretaceous periods as well as from the African region also highlighted here in green. Then these pink ones you can see they are all given in I, I, I which means the Indian origins.

So you will be able to see that Indian although it came a little bit later almost 75 millionish or 70 millionish years ago, these ancestral populations, ancestral species diverged into multiple genus in within this Southeast Asia and Indian region. So India we have a lot of bio dipterocarps genera including Vateria, Vatica, Dipterocarp, Doona, actually I myself have been to the forests of Western Ghats where I have seen these species with my own eyes and including shorea, shorea of course is found in north, right. So, so what are the, what are the you know take home messages from here? One of the take home messages is you can clearly see that the ancestral population, everything is in green, right. So the ancestral origin was from this Africal region, African region which then took over, but then it seems like when the climatic region or the climate was changing because Africa is more dry compared to the Southeast Asian region and then the dipterocarps are actually following the climatic pattern, okay. And now what the extent

or the living species or genera that happens in India are all these moist or tropical environment oriented, even the deciduous ones, they are moist deciduous species.

So they cannot survive in completely dry areas like what some parts of Africa is now. So with this kind of phylogenetic tree, they came up with some you know findings and said that the dispersal of dipterocarpaceae probably happened from Africa to India. I am always using this word probably because as I said even if the this paper says you know it has happened, but you should always use this probably word because you know all these are hypothesis and new evidence of fossil can always distort your previous finding. You know tomorrow I somebody finds a fossil which is maybe 200 million years ago of a dipterocarp, then this whole tree will change, right. That is the reason I am always using probably.

The dispersal of dipterocarp from have happened probably from Africa to India and most likely have taken place where same or similar climatic conditions prevailed in the adjacent landmasses. So probably the landmasses which were together at that time were similar climatic condition, then owing to continental drift when the landmass has separated, these climatic conditions started becoming different and different, okay. And that is how speciation in those isolated landmasses happened separately, okay. So what we are talking about allopatric speciation and sympatric speciation in those islands. So both are happening together.

Dipterocarpaceae then began evolving during the mid-Cretaceous as we discussed and diversified across tropical Africa as the climate shifted from here semi-arid to wet seasonal and pre-perhumid conditions, okay. Two main lineages, Monotoideae which approximately 72.1 million years ago and Dipterocarpoideae 94 million years ago and one was basically from tropical dry seasonal conditions whereas dipterocarpoideae was more wet seasonal conditions. All those pink marked ones were dipterocarpoideae mainly can be attributed to the phylogenetic niche conservatism because dry and wet different types of habitats they choose. So this is how the study was done and this gives an excellent example of allopatric speciation or sometimes the term is called Vicarians or sister species which when sea levels were low, they got the opportunity to get dispersed with those winged seed and this study also showed that sometimes in the in the middle some of these species which were speciation within some islands actually lost those winged wind fruits.

So in between some of the species did not have those wind fruits. Again, it appeared in some other species, right. So depending on where these species were and how the dispersal was happening, the fruit characteristic changes over the period of time also. So this is another fantastic evidence suggesting how sea level, lowering the sea level facilitated some of the dispersal and then after reaching some new areas how the speciation happened in those islands, okay. So sympatric and allopatric speciation. This is one of the case studies.

Now let us go to our next case study where we talk about speciation in felids. Felids are nothing but cats or felines. This we have addressed in our chapter feline fables. You can go and definitely read this chapter. Felines belong to the family of Felids, order carnivora we all know. Family is Felidae and it actually has two big subfamilies, pantherinae which are big cats, panther you know and the second is Felinae or the small cats. So these are the big family of cats which includes 41 species in the world including big and small and India actually we are very, very proud that we say that we have almost 15 species of cats which is one of, which is the most, not one of the, the most felid diverse country in the world, okay. And in iThink biology book we have actually included the pictures with reference to all these species. We will quickly go through that in a minute and you can see what are the different species found in India based on what, which habitat they occupy.

Here is the iThink biology chapter. The first one is of course none other than the Royal Bengal Tiger, panthera tigris tigris found throughout India as well as in many parts of this Java, Sumatra and all these islands. It is endangered now declared by the IUCN. None other than panthera leo or which is a subspecies of the African lions. This is found in Gujarat in the dry regions and it has extended its range even to the shorelines now.

Leopard, panthera pardus, found in the grasslands actually all over 17 states at least considered vulnerable these days because of habitat destruction. This is the snow leopard or the panthera muncia found in the mountainous regions of western Himalaya including Jammu and Kashmir, very beautiful cat. These are the clouded leopard, very rare to see actually and you can see it is categorized also as vulnerable by the IUCN, very beautiful cat. Desert cat,it's if you go to a desert it's quite common there, you are, if you roam around you can definitely see and the population is also not that bad.

Fishing cat. Fishing cat used to be very common but slowly actually it is getting more and more endangered. We also talk about fishing cat in this chapter and how it is having a lot of human animal conflict in in terms of food or fish food as resources. This is a pallas's cat, very nearly almost threatened, occurs only in the north, northern states, some of the northern states of India. Desert cat again quite common like the other desert cat. Eurasian lynx, this is also occurs in the Himalayan region but also Ladakh, China it goes through there and it is quite common in those region.

As you can see it it occurs in areas where there is heavy snowfall and it is very used to this kind of habitat. Asian golden cat found in northeast India also becoming very rare these days and near to threatened because of habitat destruction of course. Caracal is a is found in Gujarat, Madhya Pradesh, so very dry region but also very unique so it it has the ears like the lynx but it is not a snow loving species, it is more dry area species, very common. So it is says here least concern but this also is facing lot of human disturbance and threats from us.

Leopard cat, very very beautiful cat occurs in the Himalayan foothills and tropical evergreen coniferous forest. Least concern but as you know cats, the whole family, all the cats itself they are very elusive so it is very difficult to see unless you really go there and stay there. Rusty spotted spotted cat, it is an endemic species near threatened occurs in the grasslands, shrublands, western Ghats which it found. I have been very fortunate to see a few of them myself. And the Marbled cat, this is again very very beautiful cat, near threatened occurs in northeast India, Meghalaya, Arunachal, Sikkim and some parts of West Bengal and Nagaland. So these are the different cat species as you could see they occur from moist to dry to desert to snow capped mountains, different occupying different habitats which has given rise to their nice body pattern owing to the environment they have evolved in.

So let's see, let me introduce you to another term, the biogeographic realms. This is also relevant for our Dipterocarp case study because we you saw the globe some of these areas were differently colored and these are colored based on the biogeographic realms that we are going to talk about now. So biogeography is the science of documenting and understanding spatial patterns of biodiversity. However, that is not what, when it is only understanding of spatial patterns of diversity that does not comprise any biogeographic realms. Biogeographic realms more make sense when we talk about in space and time in the geological time.

For example, how large areas of the earth within which organisms have evolved and over time periods they have been characterized by these evolutionary histories, okay. So what do they mean by this? Let's see the example, there are eight biogeographic realms, seven are given here, one is the Arctic and the you know Arctic and Antarctic is not included, but all the others are here. So if you talk aboutbio biogeographic realm, the green one is the, called the Neartic. Okay, so these are the new world species and comprises mostly of the, you know, the towards the Arctic tundra and from Palearctic to Neartic.

So they have temperate regions, they have some taigas, some tundra where are snow-capped peaks where hardly anything occurs and then if you go to the Indomalayan region which is this brown region, you can also find this diagram as well as the descriptions in our book. Please I encourage you to go and look there and read about it and if you see this, you know, Eurasian is the big chunk here, the red and this has very typical of its flora and fauna as well as Indomalaya or Indian region, very unique species collection and you can see although this Indomalaya region is very smaller compared to a lot of other biogeographic zone, this is actually one of the highest richness and endemism in this area it occurs because of its placement, because of the different continental plates mixing and matching and fitting each other and you know mix of species coming together, okay. So, this defines the biogeographic realms. Why it is important for this case study? So here is the relevance of it.

Johnson et al. 2001 studied felines or felids, the whole group of cats using X-linked, Y-linked

and mitochondrial gene segments and why this biogeographical realm or geogeographical realm becomes important is you can see from this phylogenetic tree. So 16 fossil calibrations define 8 principal lineages, okay. So they, they could identify 8 principal lineages as you can see and these were all 1, 2, 3, 4, 5, 6, 7 and 8 last one. So these were all the lineages they could identify and at least 10 intercontinental migrations which they thought facilitated by the sea level rise and lower level, so fluctuations of the sea level. So what can we see from here? We will for now ignore this part of the diagram, but this part of the tree, but let's start from this basal point.

Say if this is the ancestral population almost approximately 11 million years ago, which is the myocene, it is called myocene radiation also. So during this time, one thing to keep in mind, this myocene radiation not only happened in felids, but it also happened in lot of monkeys, apes and particularly because just before this the sea level was lower and lot of these animals could actually cross or migrate intercontinentally. So this is just an example of the cat family. So approximately 11 billion years ago, it started radiating or migrating and you can see the blue ones which are the Indian population. These included tiger, clouded leopard and this full-clayed Bay cat, Asian golden cat, Marble cat and also some some in the sixth clade.

So the pattern here what I am trying to say is in India as well as this pink region, you will see that these species are clustered under different genera or different lineages, okay. But note that one thing to be noted here is this particular lineage. These two lineages are only in purple color okay and these one is puma and one is the leopardus or the Ocelot lineage. So these are the two only occurred in South America and which suggests that in South America, migration or expansion of range through migration happened only twice.

Once approximately 6.5 million years ago and the next probably 7, sorry 8.5 million years ago and next probably 7.2 million years ago where these two lineages diverged and settled in certain parts of these of this continent whereas others all the species actually originated from these parental populations, right. So if you go back to our speciation lecture where we talked about allopatric speciation and sympatric speciation, you can see these spread is what allopatric speciation caused whereas these in this purple color probably all were sympatric speciation within the same region they actually diverged based on niche requirement, based on reproductive isolation of some kind and this is how it actually happened. This is a very good example of what we talked about in the speciation lecture.

And these were their findings. Origin of some cat species such as tiger which happened in Southeast Asian region, but it was also India has such biodiversity because it was also connected to the migratory pathways of many of these felids, okay. So it it came, settled and then it again moved into different continent, but it diverged even in within our Southeast Asian region. Different continental plates provided similar habitats for newly colonizing species from different parts of the world, right. And diversification happened through mostly colonization in India

because as you see as I said, you know the blue is scattered in the phylogenetic tree if you can see. In contrast to the neotropical region which is the South American region which has only two lineages suggesting probably sympatric speciation as occurred, okay.

So I'm hope as we talked about you know different ways through how speciation happens in the previous lecture, sympatric, allopatric, parapatric and peripatric, hope you remember those. And we talked inthese this lecture about two case studies using phylogenetic trees and how continental drift and sympatric allopatric speciation have happened in these two examples. And we also came to know about the different biogeographical realms which can help us understand the distribution of and evolution of these species across the globe. I hope you enjoyed this lecture and my I think question is which type of speciation would you think be common in most common in plants? Okay, join me for the live interactive session when we talk more about this. Thank you for attending this.